



Spot and Runway Departure Advisor (SARDA)

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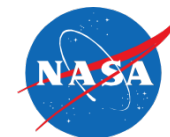
SARDA Overview



SARDA technology highlights from NASA simulations



What are the problems?



- **Today's Airport Surface Operations:**
 - Demand-capacity imbalance at major airports
 - Uncertainties in surface events
 - Lack of shared situational awareness and coordination
- **Consequences:**
 - Surface congestion and long queues
 - Excessive taxi delay and fuel/emissions
 - Poor predictability

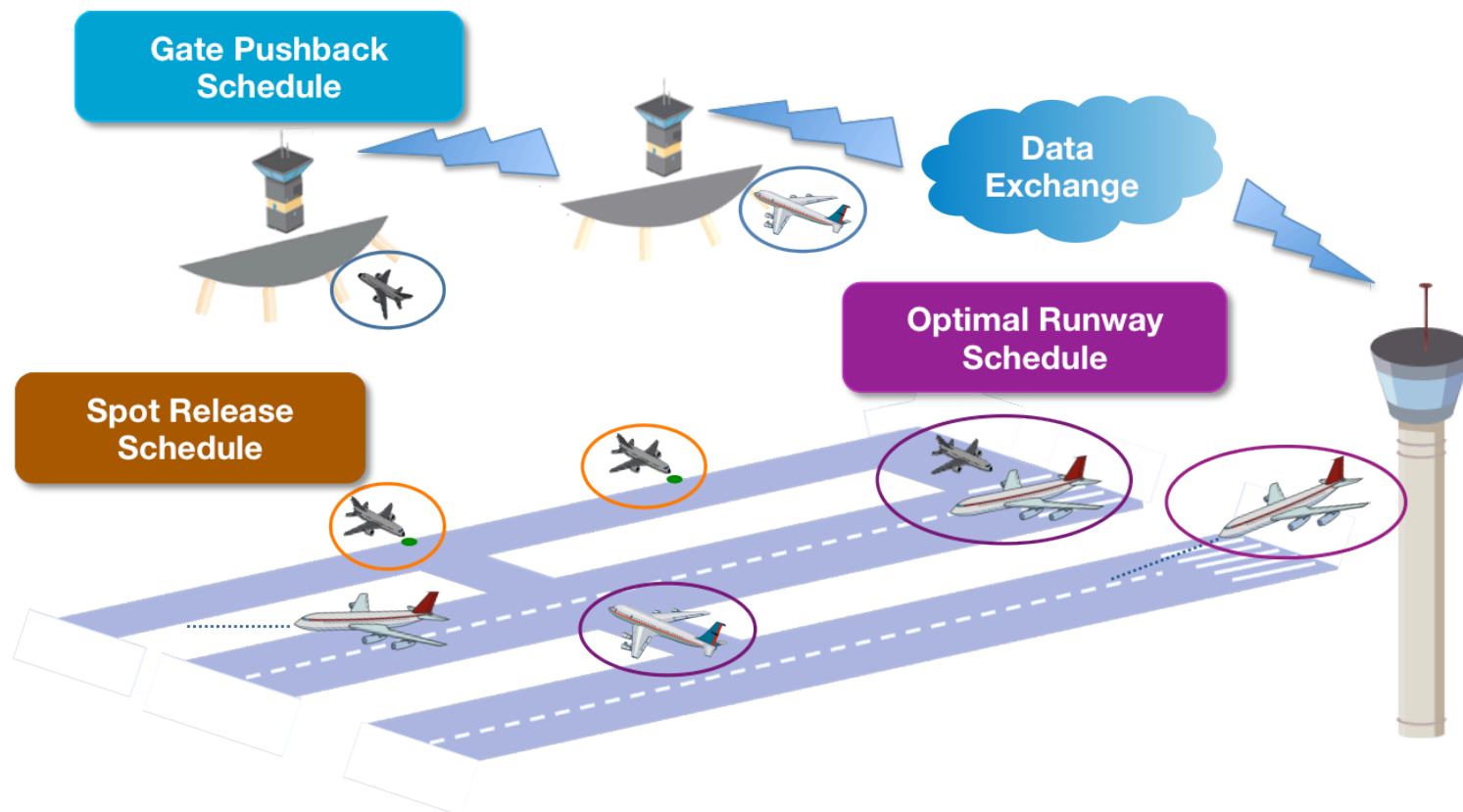


SARDA Concept



NASA's Departure Management Tool Based on Intelligent Surface Scheduling

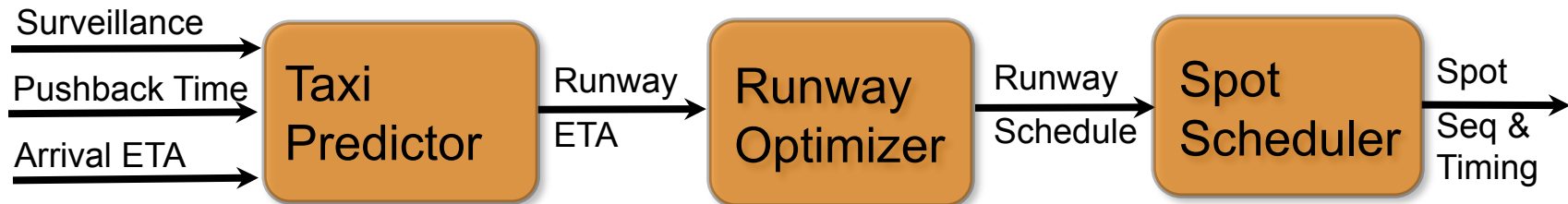
- Builds an optimal runway schedule
- Generates spot release sequence and timing
- Determines when to push back from gates



SARDA as ATC Tower Tool



SARDA takes inputs from multiple sources and computes advisories for runway usage and spot release



Local - Runway Sequence



Ground - Spot Release



SARDA Ground Controller Advisories



11:21:54 Fund Control

East Ground Control Recall FFT1873 E Local Undo FFT1873: TX-D 18:21:53

East Ramps - Departure

FFT1384	A319	15	11:15	S47/K...EF	17R/SOL/ATL	1843	TX-D
AAL1502	MD83	14	10:15	S7/JY...EH	17R/CLR/MSY		TX-D
AWE558	A320	13	08:01	S42/EL...EH	17R/CLR/BTR		TX-D
UAL121	A320	12	06:38	S45/K...EF	17R/SOL/ATL	1838	TX-D
AAL2282	MD83	11	06:12	S15/K6...EG	17R/AKU/XNA		TX-D
DAL415	B737	10	06:06	S47/K.EG	17R/GRA/BLE		TX-D
AAL575	B752	9	05:29	S7/JY...EH	17R/ARD/MSY		TX-D
DAL974	B737	8	04:52	S42/EL...EG	17R/AKU/MSN		TX-D
AAL1286	MD83	7	04:41	S9/K.EG	17R/AKU/PIA		TX-D
FFT2078	A319	6	04:39	S47/K...EH	17R/CLR/BTR		TX-D
FFT1264	A319	5	03:50	S45/K...EH	17R/ARD/MSY		TX-D
AWE439	A320	4	03:26	S33/K...EF	17R/SOL/ATL	1833	TX-D
AWE964	A320	3	02:20	S31/K...EH	17R/CLR/MCO		TX-D
AAL943	MD82	2	01:39	S22/EK...EH	17R/CLR/BTR		TX-D
AAL1374	MD8	1	00:58	S7/JY...EF	17R/SOL/ATL	1828	TX-D

Handoff sequence to Local controller at departure queue

FFT1873	A319	K.EG	17R/NOB/EWR	E Loc
FFT2137	A319	K.EG	17R/TRI/SJT	E Loc
AAL332	MD82	K.EG	17R/TRI/BWI	E Loc
UAL891	B772	K.EG	17R/AKU/MSN	E Loc

Drop List

Arrivals going to ramp

DAL249	MD88	M7.B	S53	TX-A
AAL636	MD82	M4...K5	S10	TX-A
AAL533	MD82	M3...EK	S24	TX-A

Taxi - Arrival

AAL56	B763	S10	RAMP
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Traffic Mgmt Initiative

Spot release advisory shows spot release sequence & time, taxi route, departure runway queue

18:21:53 ATIS D Recalc

SARDA: 2 00:55
1821@SPOT 0803@RWY

ENTER	DETECT
ADD	DELETE
CODED	MAP

SARDA Local Controller Advisories



East Local Control

East Local Control Recall Undo DAL152: ELC -> D

17R 17C

Active runway usage advisory shows sequence for arrival crossings (white) and departure take-offs (green)

Flight	Aircraft	Seq	EG	Runway	LUAW	CFTO
FFT2587	A319	6	EG	TRI/TYS	LUAW	CFTO
AWE717	A320	5	EH	CLR/MSY	LUAW	CFTO
AWE190	B737	4	EG	AKU/MKE	LUAW	CFTO
UAL900	A320	3	EF	SOL/ATL	LUAW	CFTO
AWE438	B737	2	EG	AKU/SGF	LUAW	CFTO
DAL249	MD88	1	S53	E GND		
AAL636	MD82	1	S10	E GND		
AAL533	MD82	1	S24	E GND		

Traffic Mgmt Initiative

Arrival advisories show sequence for crossing active runway and the taxi-to arrival spot

Flight	Aircraft	Seq	Runway	CTL	HS
FFT2555	A319	17	S48	CTL	HS17R
AAL612	MD82	8	S24	CTL	HS17R
FFT1652	A319	8	S46	CTL	HS17R
UAL572	A320	8	S48	CTL	HS17R

17R - Clear For Takeoff

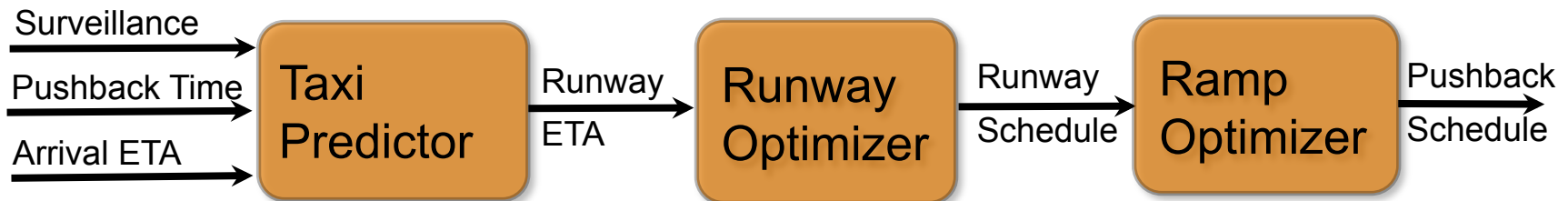
AAL994 B752 CLR/MCO DEP

18:21:16 ATIS D Recalc

SARDA as Ramp Tool



SARDA takes input from multiple sources and computes advisories for gate pushback

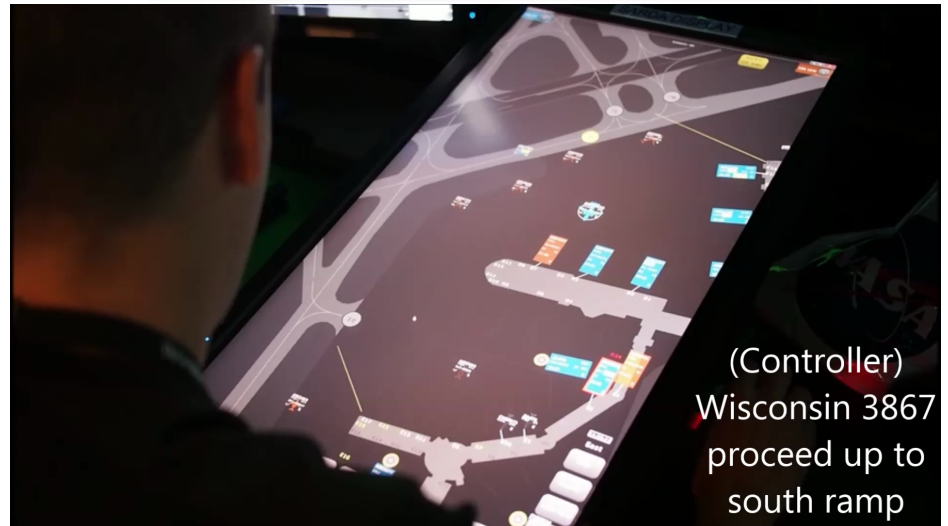
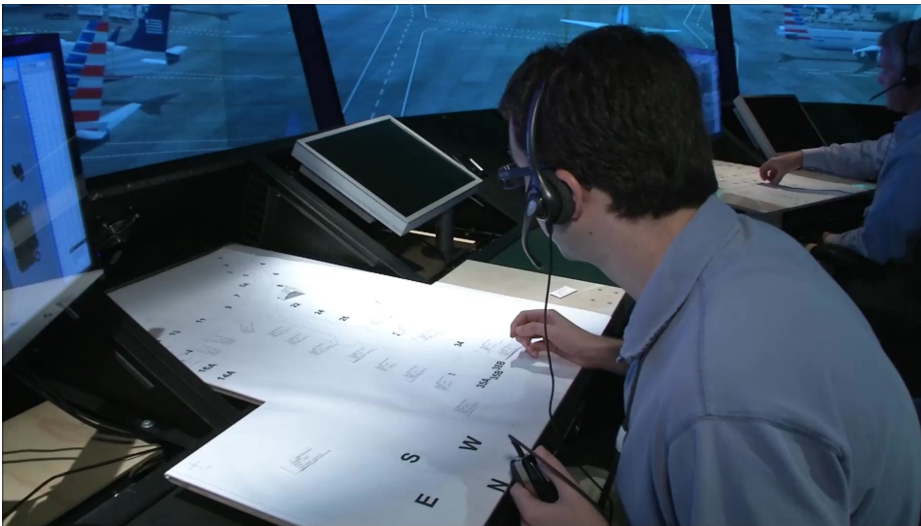


Today's Operation:

- Paper ramp area map
- Paper flight strips

SARDA Ramp Tool:

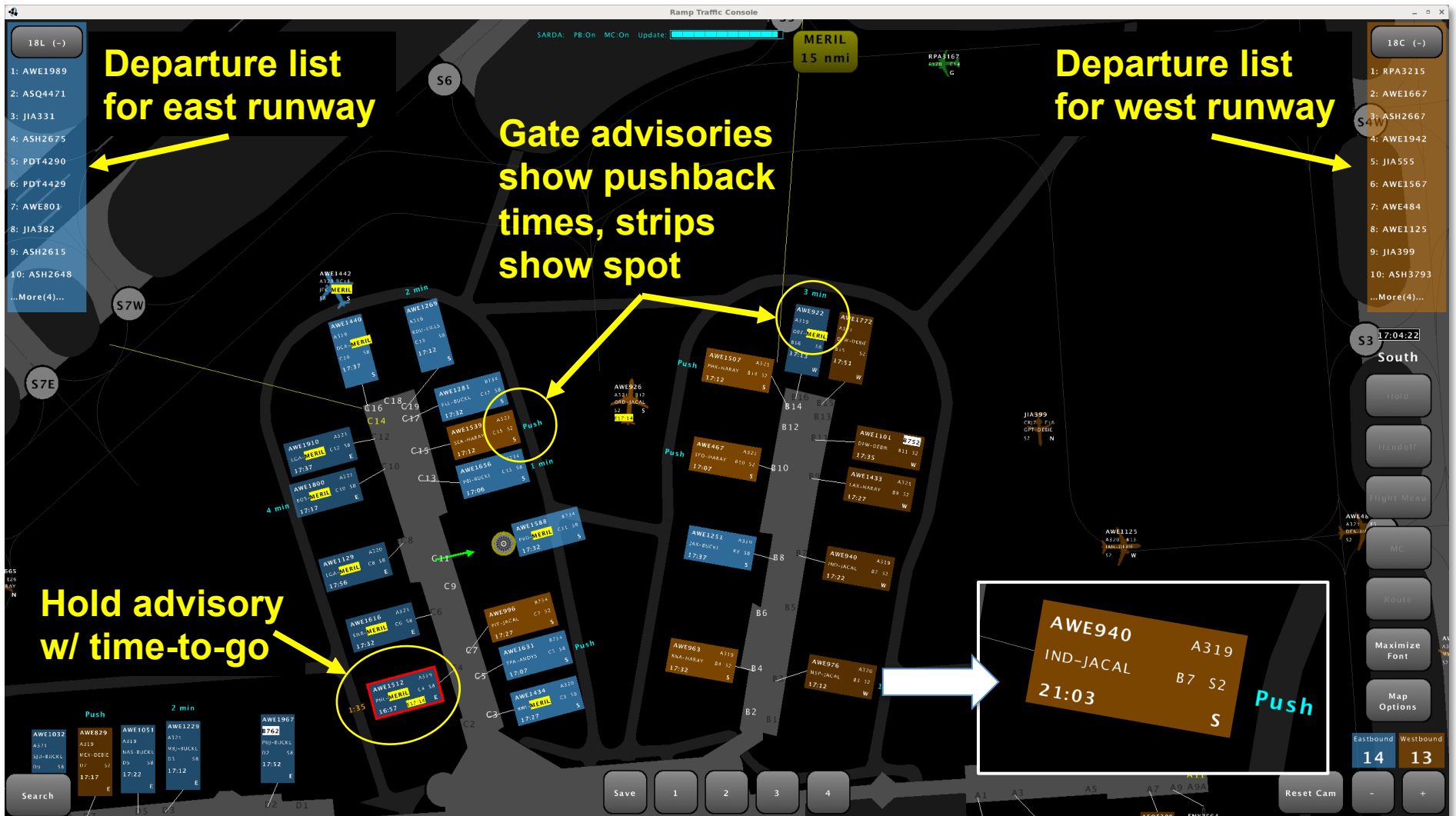
- Electronic Flight strips
- Surface map & surveillance
- Pushback advisories



SARDA Ramp Controller Advisories



Ramp Traffic Console (RTC) displays SARDA advisories on ramp surface map



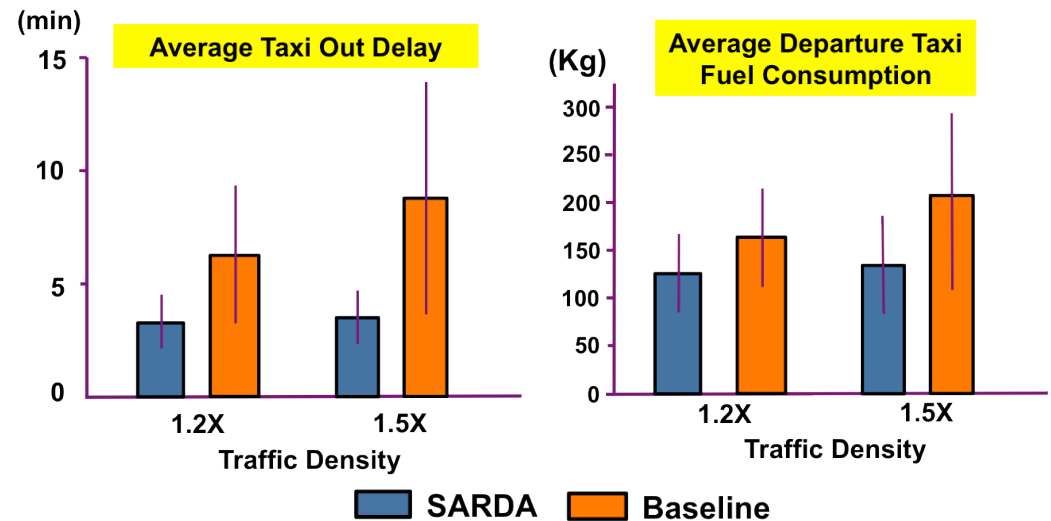
SARDA Benefits – ATC Tower Tool



- Reductions in departure taxiing delay (45% - 60%) and variability
- Reductions in fuel consumption (23 - 33%) and variability
- Consistent and accurate prediction of takeoff time
- Decreased controllers workload, less sensitive to the traffic load



Human-in-the-loop Simulation for Dallas-Fort Worth Airport (2012)



HITL - Ramp Controller Tool for CLT

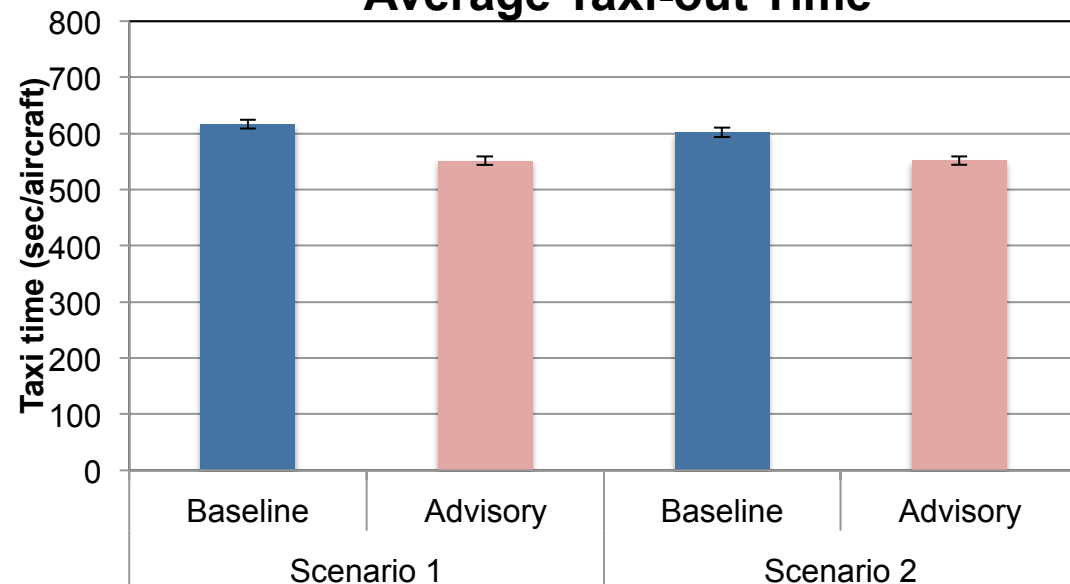


Ramp Traffic Console (RTC)



- 27" touchscreen
- Virtual strips
- Ground radar information
- Dynamic SARDA pushback time advisories

Average Taxi-out Time



1.1 min reduction in Scenario 1 (10.5%)

0.8 min reduction in Scenario 2 (8.3%)

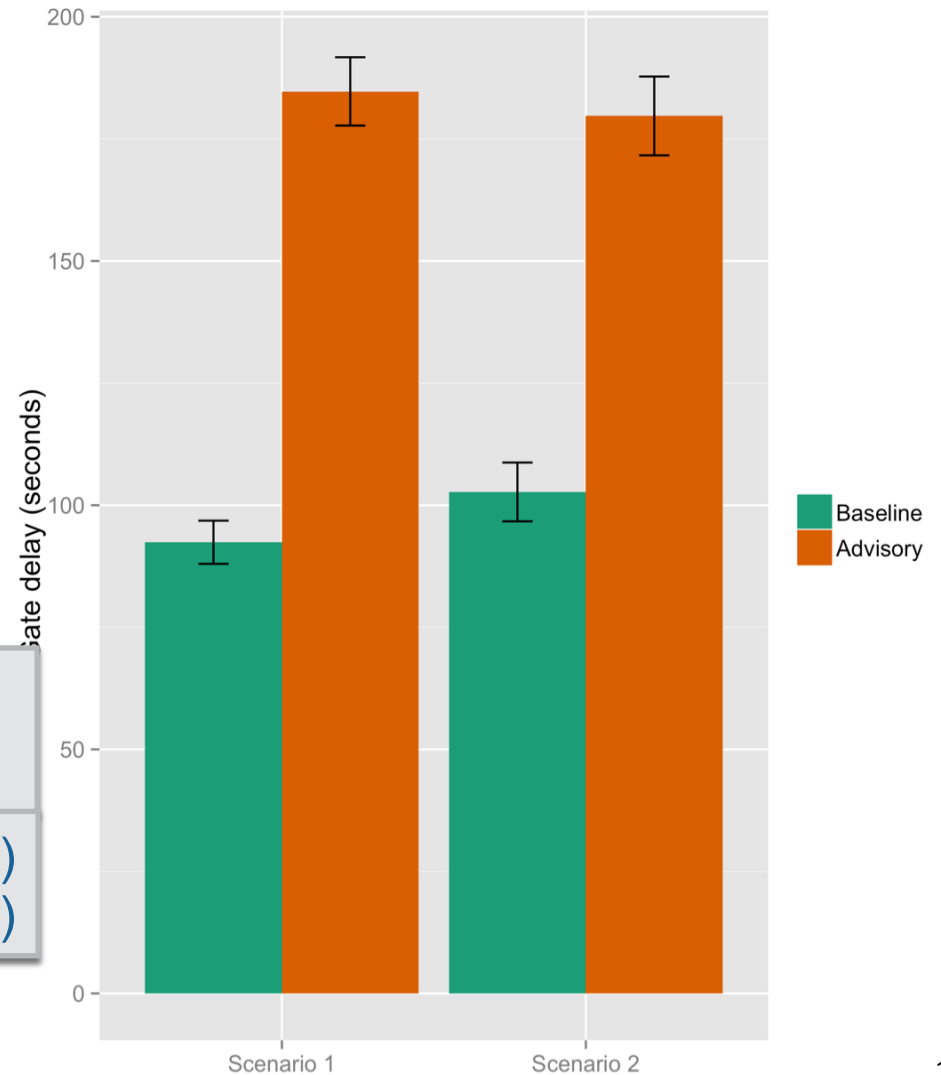
Gate Hold



$\text{gate_delay} = \text{actual_out_time} - \text{pushback_ready_time}$

Departures are held at gates longer in Advisory runs

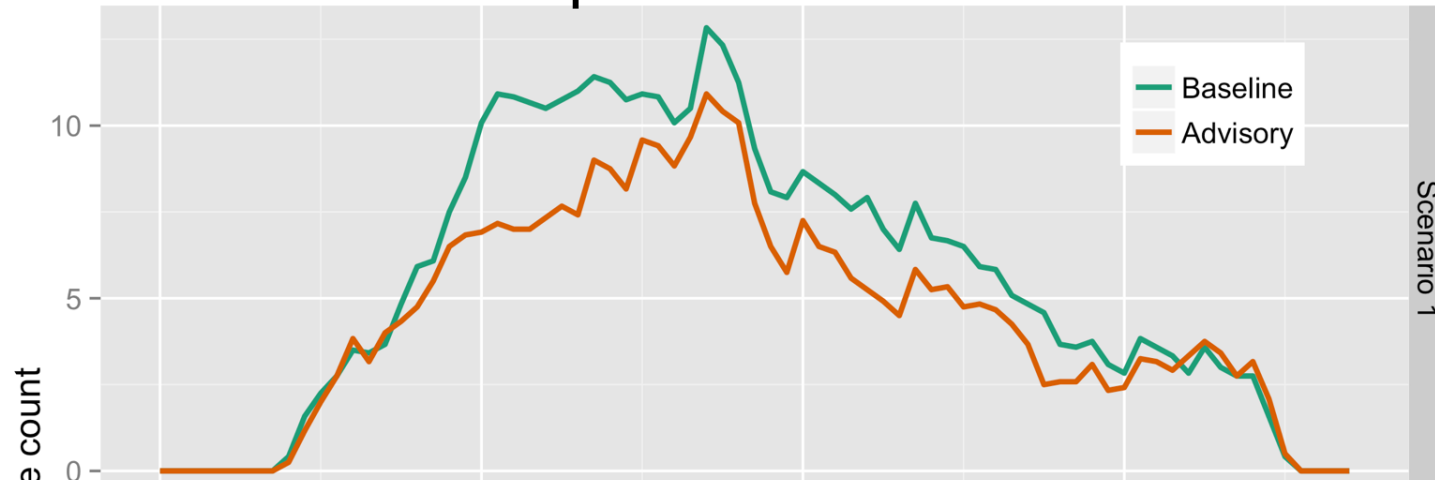
1.53 min increase in Scenario 1 (99.7%)
1.29 min increase in Scenario 2 (75.4%)



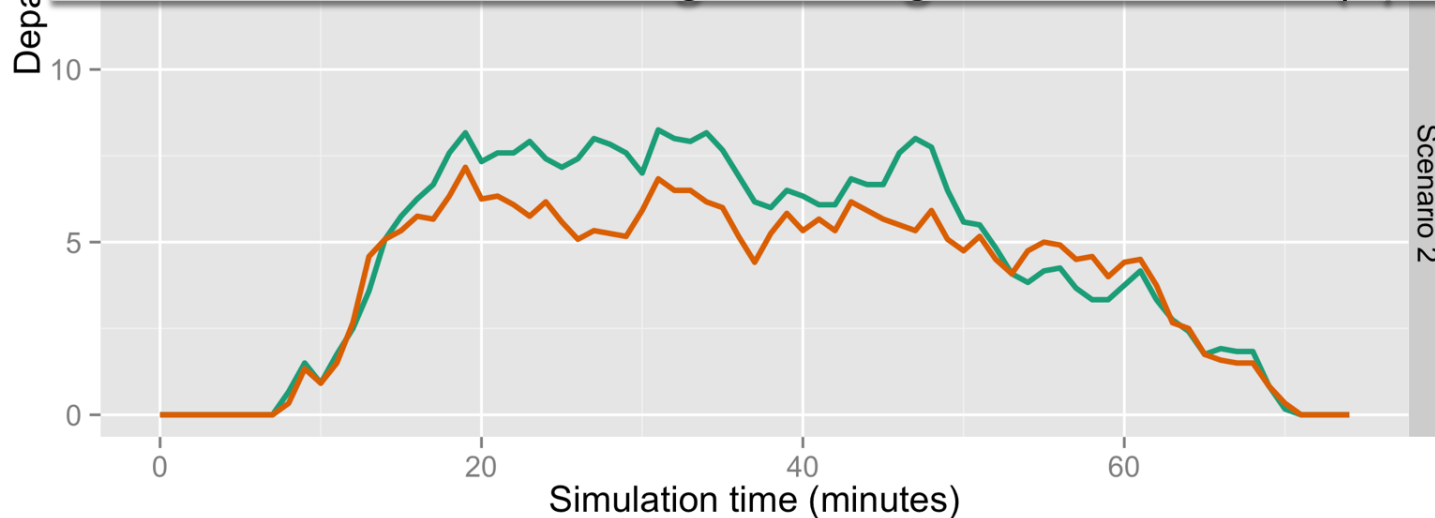
Surface Congestion



Number of departures in movement area



Number of aircraft taxiing on the ground reduced (up to 4)



Real-Time Workload Ratings



Linear Mixed Model repeated-measures analysis:

- In Advisory runs, the FAA tower controllers' ratings were reduced by 0.23 in 7 point scale ($p = 0.021$).

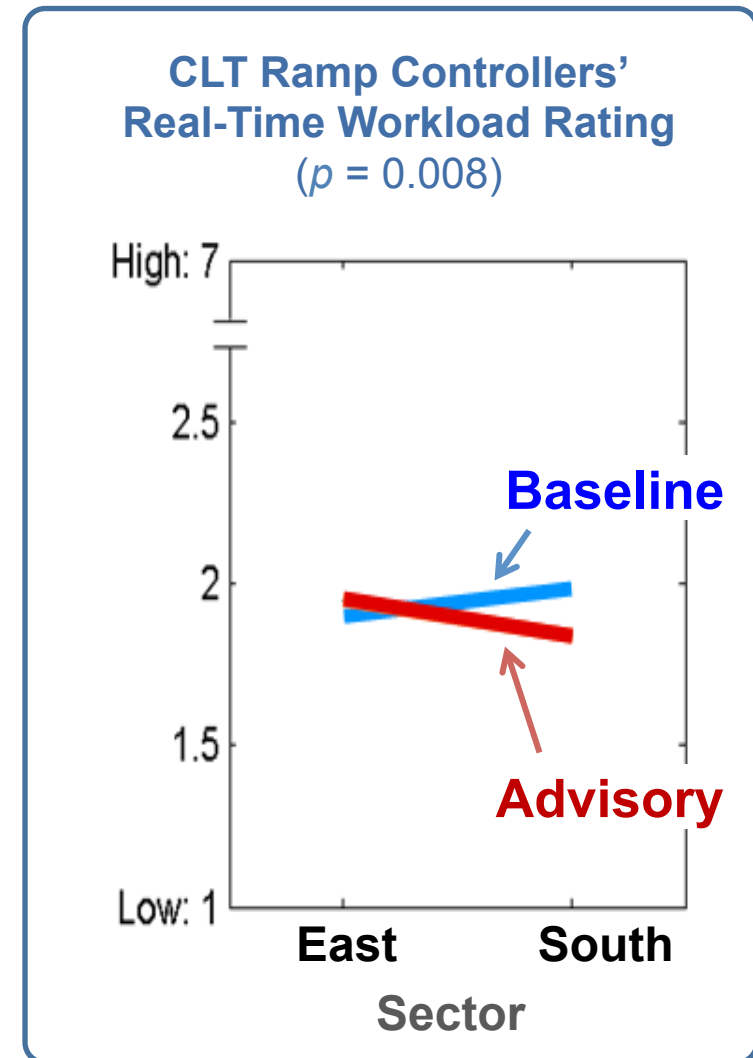
- The CLT ramp controllers' ratings:

In South Sector:

Advisory < Baseline

In East Sector:

Advisory \cong Baseline



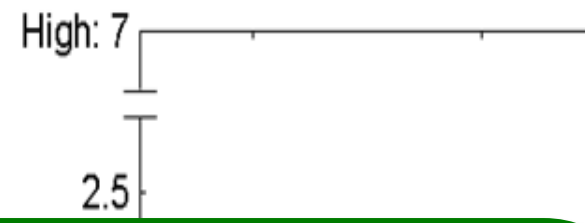
Real-Time Workload Ratings



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**CLT Ramp Controllers'
Real-Time Workload Rating**
($p = 0.008$)



- “More difficult to manage the EDCTs with paper strips”
“RTC wraps the information up all in one package”
“Easier to plan with RTC”
“Easier to visualize what is going on across the whole ramp using RTC”
“Paper strips and maps should be put in a time capsule”

Summary and Next Steps



- SARDA provides a departure metering capability by optimally scheduling aircraft on airport surface.
- SARDA enables reduction in engine-on time by holding departures at their gates and provides better predictability.
- Human-in-the-loop simulation results of both ATC and ramp tools showed reductions in taxi delay, queue size, and fuel use.
- Currently, ramp controller advisory tool is used to provide the tactical surface scheduling capability for ATD-2 IADS technology demonstration.

Thank you!



For more information go to:
www.aviationsystems.arc.nasa.gov